

than both those of first and third regions and consequently low RI also. The second region acts as a barrier to prevent diffusion of the active dopant.

Reference may also be made to US Patent No. 5474588 (1995) by Tanaka, D. et. al., 'Solution doping of a silica with erbium, aluminium and phosphorus to form an optical fiber' wherein a manufacturing method for Er doped silica is described in which silica glass soot is deposited on a seed rod (VAD apparatus) to form a porous soot preform, dipping the said preform into an ethanol solution containing an erbium compound, an aluminium compound and a phosphoric ester, and desiccating said preform to form Er, Al and P containing soot preform. The desiccation is carried out for a period of 24 -240 hours at a temperature of 60° - 70 °C in an atmosphere of nitrogen gas or inert gas. This desiccated soot preform is heated and dehydrated for a period of 2.5 - 3.5 hours at a temperature of 950° - 1050 °C in an atmosphere of helium gas containing 0.25 to 0.35% chlorine gas and further heated for a period of 3-5 hours at a temperature of 1400° - 1600°C to render it transparent, thereby forming an erbium doped glass preform. The segregation of  $AlCl_3$  in the preform formation process is suppressed due to the presence of phosphorus and as a result, the doping concentration of Al ions can be set to a high level (>3 wt%). The dopant concentration and component ratio of Er, Al and P ions are claimed to be extremely accurate and homogeneous in radial as well as in longitudinal directions.

Reference may also be made to US Patent No. 5123940 (1992) by DiGiovanni et. al., 'Sol-Gel doping of optical fibre preform' wherein the method comprises collapsing a silica - based glass tube to make a preform and drawing fibre from the preform. Before collapsing the tube, one or more glass layers are formed in the inner surface of the glass tube by dip-coating with a stable dispersion (sol) containing the metal-alkoxides and dopant cations including RE-ions. The metal-alkoxides dissolved in an alcoholic or aqueous solvent contains required quantity of the dopants, polymerising the sol to form a gel, drying and sintering the tube. A wide variety of dopant materials, in the form of salts or alkoxides are easily incorporated by dissolving them in the solvent. The method suffers disadvantage that there is a possibility of evaporation of the RE-salts during sintering at high temperature,

there by causing inhomogeneous distribution of RE-ions through out the length of the preform.

Reference may also be made to the publication by Matejec et al., 'Properties of optical fibre preforms prepared by inner coating of substrates tubes' *Ceramics-Silicaty*, **45** (2), 62 (2001) wherein the method consists of collapsing a silica based glass tube containing the required dopant cations to a preform and drawing fibre from the preform. Before collapsing the tube, one or more glass layers are formed in the inner surface of the glass tube by raising and lowering the sol level at a fixed velocity. The sol contained the silicon tetraethoxide (TEOS) and dopant cations including RE-ions. The TEOS dissolved in an alcoholic or aqueous solvent contains required quantity of the dopants, polymerizing the sol to form a gel followed by drying and sintering the tube. The main disadvantage of the method is that there is every possibility of evaporation of the RE salts during sintering at high temperature, resulting in an inhomogeneous distribution of RE-ions throughout the length of the preform.

**A few of the drawbacks of the above mentioned processes are as follows:**

1. Deposition of porous silica soot layer at a temperature of 1200 - 1400 °C by Chemical Vapour Deposition (CVD) process inside a substrate silica tube or on a seed rod ( VAD or OVD apparatus).
2. The porosity of the soot layer controls the RE incorporation and the homogeneity along the length of the preform.
3. The control of porosity of the deposited unsintered layer is difficult as it is extremely sensitive to the deposition temperature, burner traverse speed and flow of the reactant materials. This leads to variation in soot density and composition along the length of the tube.
4. The dipping procedure of the soot containing preform into the RE solution is critical due to the possibility of generation of local imperfections and concentration variation in the core of the preform.

5. Minor variation in dipping parameters coupled with the porosity of the unsintered soot layer leads to considerable change in RE concentration as well as radial distribution in the core of the preform.
6. The dipping parameters and the porosity of the soot layer are critical to obtain good core-clad interface and minimise attenuation of the fibre.
7. The dopant materials are concentrated in the pores of the deposited layer. As a result, clusters or microcrystallites of dopants tend to form both before sintering and during the steps of sintering and collapsing of the glass materials, giving rise to inhomogeneous distribution of the dopant materials.
8. Formation of microcrystallites causes scattering of light and increases the attenuation of the fibre.
9. Evaporation of the solvent leaves behind a residue containing the salt of the dopant cations or RE oxychloride which during dehydration in the chlorine atmosphere or sintering at high temperature volatilises, creating a dip in concentration near the inner surface of the porous layer.
10. Dehydration and sintering of the RE chloride impregnated soot layer give rise to compositional variation due to the vaporization of the dopant salt as well as  $\text{GeO}_2$  in the core.
11. The process suffers from reliability / repeatability due to its sensitivity to the parameters during various stages of processing such as deposition, solution doping, drying and sintering.

#### **Objects of the invention:**

The main object of the present invention is to provide a process for making rare earth doped optical fibre which obviates the drawbacks as detailed above.

Another object of the present invention is to provide a method of fabricating RE doped preforms and optical fibres by using RE coated silica nanoparticles as precursors.

Still another object of the present invention is to prepare RE (Er, Nd, Eu etc.) coated silica nanoparticles by a known technique. (Ref: 'Sonochemical Preparation and Characterization of  $\text{Eu}_2\text{O}_3$  and  $\text{Tb}_2\text{O}_3$  Doped in and Coated on Silica and Alumina Nanoparticles', A.Patra,